NGST Systems Engineering Report

Thermal Subsystem 11

Title: **Required Parallel Layer Sun Shield Performance Versus Number of Layers and Layer Spacing**	
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References:	

Description

This SER quantifies the relationship between NGST's sunshield performance and desired OTA temperature. Sunshield performance is then related to the number of layers and layer spacing of a parallel membrane sunshield configuration. The NGST NASA yardstick configuration was used for the analysis.

Sunshield Performance

Required sunshield performance is determined based on the desired OTA operating temperature. Naturally as the desired OTA temperature is lowered, the sunshield's thermal performance must increase. Since the OTA's temperature is driven by the temperature of the OTA facing sunshield

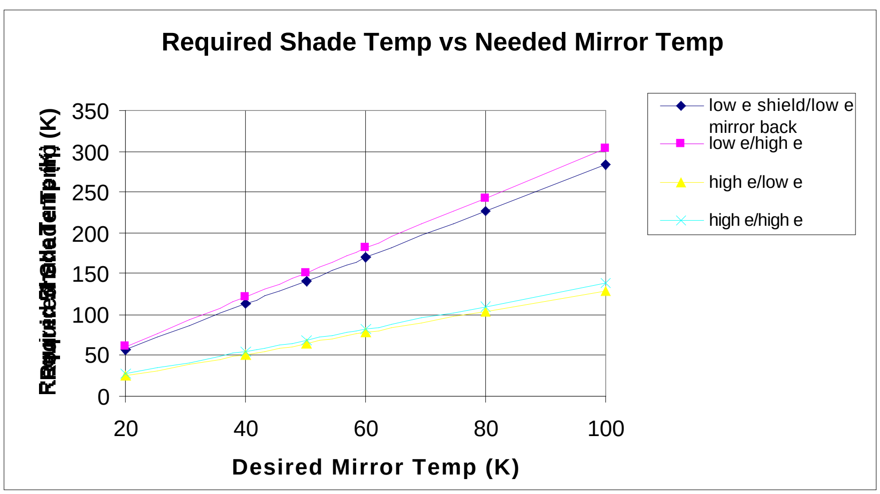

Figure 1

layer, OTA temperature can be related to the last layers temperature. Figure 1 illustrates this relationship for a combination of low and high emittance shade layer and low and high emittance primary mirror back. The OTA's temperature dependence on the OTA facing shield layer is easily determined from the optical properties of the OTA and shield layer and from the configuration view factor between the OTA and sunshield. The view factor used in producing Figure 1 was determined from detailed thermal geometry models of the yardstick configuration.

Once the desired mirror temperature is related to the cold side sunshield temperature, the necessary shield thermal performance can be determined. The required thermal performance of the shade can be quantified by determining the effective emittance or ε* of the shield. ε* is typically used the quantify the thermal performance of multi-layer insulation. The amount of heat flow through the sunshield, which determines the cold side layer temperature and thus the OTA's temperature, is quantified by using the following equation:

$$Q = \varepsilon * A\sigma\,(T^4{}_{sunside} - T^4{}_{otaside})$$

where A is the sunshield's total area and σ is the Stefan-Boltzmann constant. The lower the effective emittance, the better isolation provided by the sunshield. Using the information found in Figure 1, and assuming a sunside shield layer temperature of 395 K, the relationship between required ε* and OTA temperature can easily be determined. The results are illustrated in Figure 2. Note that as the needed mirror temperature drops, the required ε* can easily decrease by

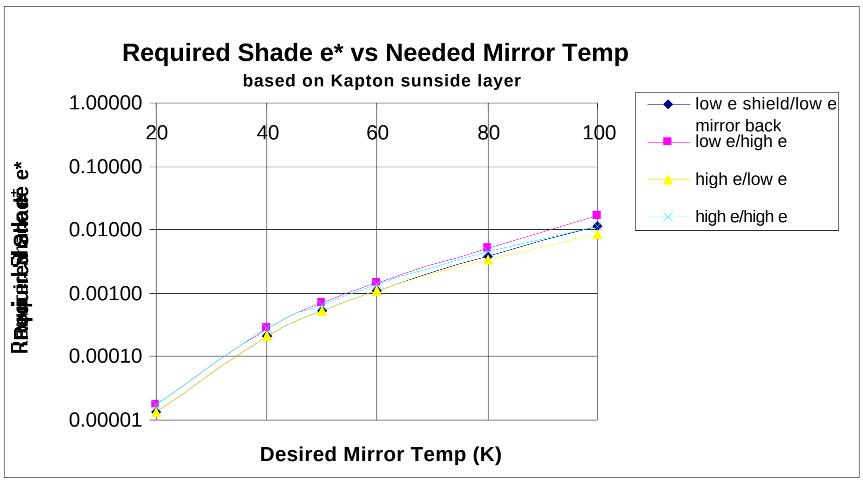

Figure 2

orders of magnitude. Although Figure 2 illustrates the relationship for high and low emittance surfaces on the cold side shield layer and the primary mirror's back, there is only impact on required ε*.

ε* Based on Number of Layers and Layer Spacing.

Assuming parallel layers and diffuse properties on the inner layer surfaces, ε* was then related to the number of shield layers and the spacing between them. ε* can be improved by either adding layers or by increasing the spacing between them. A simple thermal model of two unit area shield layers was constructed and the radiative interchange factors between the layers was determined for a variety of spacing. The spacing between the layers has been quantified by using a dimensionless quantity designated the layer spacing factor. The layer spacing factor is useful when comparing the spacing of shield layers using different shield shapes and configurations. The layer spacing factor is defined as the ratio of edge gap perimeter area between the two layers to the total area of the layer as a percentage. This is illustrated in Figure 3. Once the radiation interchange factors for various layer spacing factors were determined, this information was applied to multiple layers and the relationship between spacing and total number of layers was determined. This is also illustrated in Figure 3. Using Figure 3 along with Figure 2, the needed parallel shield configuration for a specific OTA temperature can easily be determined. Thse simple models of shield performance are not intended to replace the necessary detailed thermal modeling of a chosen configuration, but are to only as a guide to shield thermal performance. Figure 3 also illustrates the dramatic impact that edge gap effects have on thermal performance by showing the performance of typical multi-layer insulation (MLI). It is clear that typical MLI could never attenuate the sun's energy enough to passively cool NGST's primary optics.

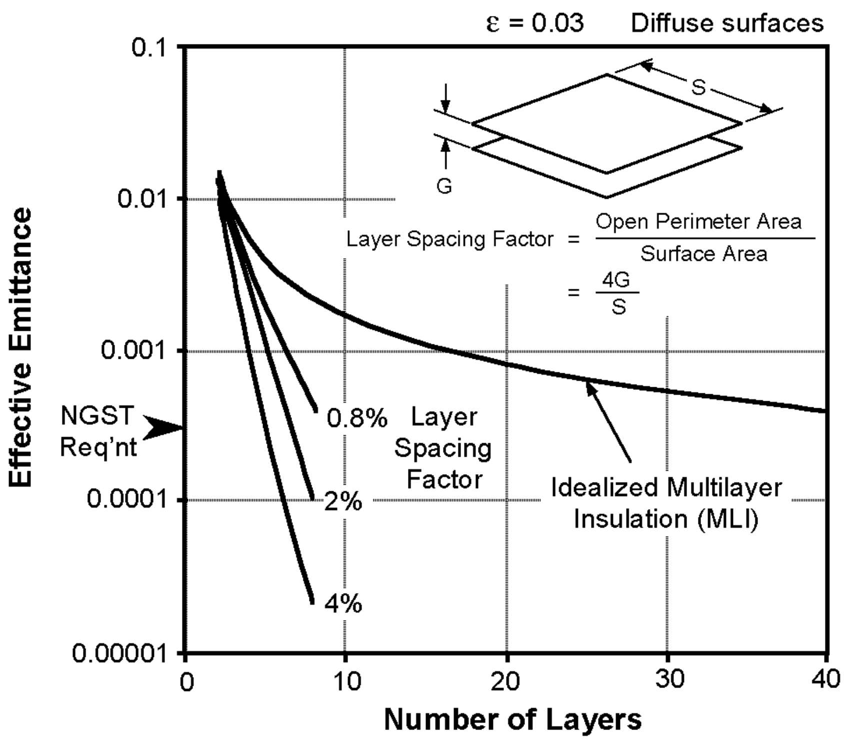

Figure 3 ε* Dependence on Layer Spacing